Water Quality Index (WQI) under Climate Change Impact

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Abstract
In this study, surface water quality indices and water quality parameters under various climate change scenarios were modeled. Climate data were extracted from the Canadian Coupled General Climate Model (CCCM3.1/T63) under the greenhouse gas emission scenarios B1 and A2. The surface water quality of 15 rivers of New Brunswick on the basis of 9 parameters using climate change scenarios B1 and A2 were analyzed. A weighted method and the Canadian Council of Ministers of the Environment (CCME) method were used to assess the water quality for each river under present and future climate. The knowledge gained from this study will enable engineers and water resources managers to better understand the rivers' thermal regime and climate change impact on water quality related to Drinking Surface Water.

Study area
The study area consists of 15 rivers in New Brunswick. New Brunswick lies on Canada’s Atlantic coast, and is bordered by the ocean on its southern (Bay of Fundy), northern and eastern (Gulf of St. Lawrence) shores. Generally, average air temperatures in New Brunswick range from -10°C in January to 19°C in July. New Brunswick receives approximately 1100 mm of precipitation annually, with 20 to 33% falling in the form of snow. Precipitation tends to be highest in the southern parts of the province and the northern part of New Brunswick receives correspondingly higher amounts of precipitation in the form of snow due to colder winters.

Water Quality Index (WQI)

1-CCME WQI Method
CCME WQI = \( \frac{F_1 + F_2 + F_3}{1.732} \)

- \( F_1(\text{Scope}) = \frac{\text{Number of failed variables}}{100} \) as a percentage of variables
- \( F_2(\text{Frequency}) = \frac{\text{Number of failed tests}}{\text{Total number of tests}} \) as a percentage of tests
- \( F_3(\text{Amplitude}) = \frac{\text{Average excursion}}{\text{Target range}} \)

\( \text{excur}= \frac{\text{TestValue} \times \text{Factor}} \text{Target} \times 100 \)

\( \text{excur} = \frac{\text{TestValue} - \text{Target}}{\text{Target}} \times 100 \)

WQI Ranking

95-100 Excellent
80-94 Good
65-79 Fair
45-64 Marginal
0-44 Poor

2-Weighted WQI Method

\[ WQI = \sum \frac{C_i P_i}{L_i} \]

C: Normalized value of the water quality parameters; P: Relative weight (1 to 4):
- P4: most important
- P2: minor importance

Weighted WQI parameters and objectives

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<th>Parameter</th>
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<th>30</th>
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Climate change modelling
Climate data were extracted from the Canadian Coupled Global Climate Model (CCCM3.1/T63) under the greenhouse gas emission scenarios 20C3M, B1 and A2 defined by the Intergovernmental Panel on Climate Change (IPCC).

Water temperature in New Brunswick, for all future time slices (2020’s, 2050’s or 2080’s) and scenarios (B1 or A2), were estimated as:

\[ T_w = T_a \times \frac{(T_0 - T_a)}{(T_0 - T_w)} \]

Results

Conclusions
- WQI values for NB rivers were calculated using two methods: CCME & Weighted
- NB rivers showed "good" water quality
- Future WQI values were estimated using Ta-Tw and DO-Tw relationships
- Climate change under scenarios B1 and A2 showed little impact on WQI

References
- Climatic and Hydroscics Lab (www.umoncton.ca/hydro)